Influence of N, P, K, Ca, and Mg Rates on Leaf Macronutrient Concentration of 'Navaho' Blackberry

J.M. Spiers
USDA-ARS Small Fruit Res. Sta
Poplarville, MS 39470

J.H. Braswell
Miss. Coop. Ext. Ser.
Poplarville, MS 39470

Keywords: Plant nutrition, fertilization, *Rubus*

Abstract

'Navaho' blackberry plants were grown in sand culture for two years and fertilized with solutions consisting of five macro nutrients (N, P, K, Ca, and Mg) applied at three different rates (0 mg/l, control and 10X control). Foliar samples were collected at 4, 8, and 16 weeks after treatment initiation during the second growing season. The 10X N rate resulted in high leaf concentrations of N and P but lower leaf concentrations of K, Ca, and Mg. High P rates increased leaf P only. The 10X K rate inhibited Ca and Mg uptake but increased the leaf contents of K. High Ca fertilization increased Ca leaf content and decreased the uptake of Mg. The 10X rate of Mg increased leaf Mg content but reduced the leaf content of Ca. Toxicity and deficiency symptoms were more evident with the N, K, and Mg fertilizer treatments.

INTRODUCTION

Information on nutritional requirements for blackberry production in the Gulf Coast region of the United States is very limited. Nitrogen is the nutrient used in largest amounts and is often used to regulate cane size and number in brambles (*Rubus* species) and has been shown to decrease sugar content while increasing leaf N concentrations (Galletta and Himelrick, 1990; Papp et al., 1984). Potassium fertilization has induced Ca and Mg deficiencies in several brambles (Ljones, 1966). Potassium fertilization increased K but decreased Mg and Zn in the leaves of 'Shawnee' blackberry (Spiers, 1993). Increased N plus K fertilization decreased leaf content of Ca in 'Thornless Evergreen' blackberry (Nelson and Martin, 1986). Kowalenko (1981) working with 'Willamette' raspberry found a positive correlation between leaf Mg and Mg in the soil. In 'Cheyenne' blackberries, Mg and Ca fertilization increased plant growth after two seasons (Spiers, 1987). This study was initiated to determine the influence of wide ranges of N, P, K, Ca, and Mg fertilization on leaf elemental concentrations and plant growth characteristics of 'Navaho' blackberry on erect thornless cultivar released from Arkansas (Clark, 1992).

MATERIALS AND METHODS

The study was initiated June 1, 1993 at the USDA Small Fruit Research Laboratory in Poplarville, Mississippi. The experiment consisted of five macro nutrient elements (N, P, K, Ca, and Mg) applied at three different rates (0 mg/l, control and 10X control) (Table 1). The control treatment consisted of a standard nutrient solution consistent with recommended rates (Spiers, 1978). Experimental design was a split plot with 4 replications of the low and control rates and three replications of the high rate. In 1992, healthy two-year-old 'Navaho' blackberry plants were potted in 8 litre containers with sand media and fertilized with a complete liquid fertilizer solution throughout the summer of 1992 and during May of 1993. All plants were cut back to 20 cm on May 28, 1993. Plants were grown on benches in a shade house (20% shade) with natural daylength and temperature. The shade house had a transparent fiberglass roof to eliminate influence of rainfall. Nutrient solutions were applied daily, Monday through Friday, and all pots were flushed with water Saturday and Sunday. Treatments 1, 2, 3, 4, 5, and 6 began June 1, 1993, and treatments 7, 8, 9, 10, and 11 began July 1, 1993. Fertilizer solutions were mixed and stored in 190 liter barrels. A pump was installed in each barrel. Treatments were applied using the pump, an attached hose and nozzle. Each pot was filled to the rim with the appropriate fertilizer treatment, completely drenching the media. Leaf samples were taken 4, 8, and 16 weeks after treatment initiation during the second growing season. At the end of the second year, plants were cut to ground level and dry weight determined. Analysis of variance and regression were performed on treatment effects. Correlations (Pearson, 1990) between elemental leaf concentrations were determined.

RESULTS AND DISCUSSION

Increased N fertilization resulted in linear increases in leaf concentrations of N and P and decreases in leaf K and Mg (Table 2). Leaf Ca also decreased (significantly when determined by LSD $P \geq 0.05$) with increasing levels of applied N but not linearly. The highest levels of leaf Ca, K, and Mg were found when plants received 0 mg N/l. Plants receiving 0 mg N/l exhibited stunted growth with small yellow leaves. All plants fertilized at the 10X rate were dead by the end of this study.

Increasing P fertilization resulted in a linear increase in leaf P. Leaf Ca was lowest when P fertilization was deficient, but no differences in leaf Ca were present in plants fertilized with control and 10X control rates of P. No P deficiency symptoms were evident. Leaves from plants fertilized at the 10X rate of P exhibited interveinular chlorosis and pale leaf tips.

Increased K fertilization caused an increase in leaf K and decreases in leaf Ca and Mg. Plants receiving 0 K exhibited small leaves and stunted growth and two of the four plants were dead at the end of the study.

Increasing Ca fertilization levels resulted in a linear increase in leaf Ca and a linear decrease in leaf Mg. No other leaf macronutrients were affected by Ca fertilization. No visual deficiency symptoms were present on plants fertilized with the low rate of Ca while leaves from plants receiving the 10X Ca rate were small with interveinular chlorosis and had white tips.

Increasing Mg fertilization resulted in a linear increase in leaf Mg content and linear decrease in leaf Ca and leaf K. Plants fertilized with the low rate of Mg remained vigorous in growth, but leaves showed interveinular chlorosis.

CONCLUSIONS

High levels of macronutrient fertilization resulted in increased levels of uptake of each respective macronutrient. Leaf Ca and Mg concentrations were reduced by high rates of N and K fertilization. Leaf N was influenced only by N fertilization. Leaf Ca did not differ when plants received control and 10X control rates of P fertilizer but was reduced by the low rate of P. Leaf Ca was reduced by Mg fertilization and leaf Mg was reduced by Ca fertilization. High N resulted in severe plant damage. Low K fertilization produced stunted growth. Chlorosis symptoms were evident in plants that received high P or high Ca fertilization.

Literature Cited

Clark, J.R. 1992. Blackberry production and cultivars in North America east of the Rocky Mountains. Fruit Var. J.46: 217-222.

Crandall, P.C. 1995. Bramble Production: Haworth Press, Inc., New York, NY. 213pp.

Galletta, C.J. and Hemilrick, D.C. 1990. Small Fruit Crop Management, pp. 157-213. Prentice Hall Inc., Englewood Cliffs, NJ.

Kowalenko, C.G. 1981. Effects of magnesium and potassium soil applications on yields and leaf nutrient concentrations of red raspberries and on soil analysis. Commun. Soil Sci. Plant Anal. 12(8): 795-809.

Ljones, B. 1966. Bush fruits nutrient, pp. 130-142. In: N. F. Childers (ed.), Nutrition of Fruit Crops. Somerset Press, Somerville, NJ.

Nelson, E. and Martin, L.W. 1986. The relationships of soil-applied N and K to yield and quality of 'Thornless Evergreen' blackberry. HortScience 21: 1153-1154.

Pearson. 1990. SAS Procedures Guide. Version 6, Third Edition. SAS Institute Inc., Cary, NC P.210.

Papp, J., Kobzos-Papai, I. and Nagy, J. 1984. Effect of Nitrogen application on yield, leaf nutrient status and fruit chemical composition of raspberry and redcurrant varieties. Acta

Agron. Acad. Sci. Hungaricae 33: 337-343.
Spiers, J.M. 1987. Effects of K, Ca, and Mg levels and N sources on growth and leaf elemental content of ‘Cheyenne’ blackberry. HortScience 22(4): 576-577.
Spiers, J.M. 1993. Potassium and sodium fertilization affects leaf nutrient content and growth of ‘Shawnee’ blackberry. J. of Plant Nutrition 16(2): 297-303.

Tables

Table 1. Chemical content (mg/1) of treatment solutions — Treatment

		1	2	3	4	5	6	7	8	9	10	11
Element	Chemical	Control	-N	-P	-K	-Ca	-Mg	10N	10P	10K	10Ca	10Mg
N	NH_4NO_3	100		100	100	100	100	1000		100	100	100
N	$(NH_4)_2PO_4$								100			
P	$(NH_4)_2PO_4$								111			
P	$NaH_2PO_4H_2O$	20	20		20	20	20	50	89	20	20	20
K	KCI	50	50	50		50	50		50	250	50	50
K	K_2SO_4									250		
Ca	$CaCl_22H_2O$	80	80	80	80		40	80	80	80	400	80
Ca	$CaSO_42H_2O$						40				400	
Mg	$MgSO_47H_2O$	24	24	24	24			24	24	24	24	121
Mg	$MgSO_47H_20$											121
	STEM[Y]	67	67	67	67	67	67	67	67	67	67	67

[Z] Control = recommended fertilizer solution complete with all elements.
[Y] STEM = S, 14.00%; B, 1.35%; Cu, 3.20%; Fe, 7.50%; Mn, 8.00%; Mo, 0.04%; Zn, 4.50%.

Table 2. The influence of macronutrient fertilizer rates on leaf elemental concentrations of 'Navaho' blackberries. 1994.

Treatment Macronutrient	mg/l	% N	P	K	Ca	Mg
N	0	1.86 b[z]	0.11 b	1.00 a	0.87 a	0.35 a
	100	2.79 a	0.13 b	0.81 b	0.64 b	0.31 ab
	1000	3.18 a	0.27 a	0.81 b	0.51 b	0.25 b
	Linear	[y]*	***	*	ns	**
P	0	3.01 a	0.09 b	0.78 a	0.48 b	0.25 a
	20	2.79 a	0.13 b	0.81 a	0.67 a	0.30 a
	200	3.18 a	0.32 a	0.88 a	0.64 a	0.27 a
	Linear	ns	***	ns	ns	ns
K	0	3.47 a	0.23 a	0.72 b	0.62 a	0.37 a
	50	2.80 a	0.13 b	0.87 b	0.70 a	0.29 ab
	500	3.31 a	0.17 ab	1.71 a	0.26 b	0.23 b
	Linear	ns	ns	***	**	*
Ca	0	3.00 a	0.15 a	0.93 a	0.34 b	0.69 a
	80	2.79 a	0.13 a	0.80 a	0.64 a	0.31 b
	800	2.91 a	0.13 a	0.98 a	0.80 a	0.19 c
	Linear	ns	ns	ns	*	***
Mg	0	2.86 a	0.14 a	0.86 a	0.58 a	0.15 a
	24	2.79 a	0.13 a	0.81 a	0.64 a	0.34 b
	240	2.69 a	0.13 a	0.64 a	0.38 b	0.52 a
	Linear	ns	ns	*	*	***

[z]Means separation by LSD, 0.05 level.
[y] ns, *, **, *** Non-significant, and significant at 0.05, 0.01, and 0.001 levels, respectively.